Productivity in Science Nobel Laureates and their Path to Idea Acceptance

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By
Samantha DeDios

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Project Advisors:
Christine Charyton, Lecturer
Thomas Nygren, Professor & Interim Chair
Department of Psychology

Abstract

Creativity is a vital component of technological and societal advancement. Yet despite the importance of creativity to world development, creativity has remained an area of relatively little empirical study. Many creativity theorists suggest that in order for an idea to be deemed creative, the idea must be accepted by one's peers within a given discipline. Our study investigated how creative ideas become accepted for science Nobel Prize laureates. Nobel laureates were chosen for this study because previous research has established Nobel laureates as eminent creative individuals. Archival data was collected for 187 Nobel laureates from 1980-2009 in physics, chemistry, and medicine. Idea acceptance was evaluated for three key publications in the Nobel laureates' publishing careers; (1) first publication concerning their Nobel idea (FN), (2) highest cited publication concerning their Nobel idea (HN), and (3) last publication concerning their Nobel idea (LN). Using measures of academic prestige such as citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores, idea acceptance was evaluated for each key publication. We found that idea acceptance for these publications generally followed the pattern of LN < FN < HN (with HN being the most accepted publication). We also found that idea acceptance varied across prize area.

Productivity in Science Nobel Laureates and Their Path to Idea Acceptance

Creativity is a vital component of technological and societal advancement. Without creativity, little progress can be made (Rubenson & Runco, 1992; Runco, 2004). Yet despite creativity's importance to world development, it has remained one of psychology's orphans (Sternberg & Lubart, 1999). We seek to shed light on the question of how creative ideas are accepted by investigating how the creative ideas of Nobel laureates become incorporated into an existing discipline in science.

Creativity Research

There are many different ways to define creativity. The Merriam-Webster Dictionary (2010) describes the noun "creativity" as the ability to create or the quality of being creative. In psychology, creativity has been defined as an ability to produce something that is novel and appropriate (i.e. useful) (Sternberg & Lubart, 1999). Similarly in the present study, we define creativity as "a preference for thinking in novel ways and the ability to produce work that is novel and appropriate" (Charyton, 2008). In previous creativity research, however, creativity has been broken down into smaller components where creativity can be discussed at four different levels: the person, process, product, or press or environment (Plucker & Renzulli, 1999; Runco, 2004).

The creative person includes an individual's personal characteristics, for instance personality, which may make them creative (Runco, 2004). Research on eminent creative individuals, such as Nobel laureates, fall into this category. Historically, the creative person has been studied using self-report measures, and measures using external ratings of past behavior, personality, and attainments (Plucker & Renzulli, 1999). Most of the previous research conducted on eminent creative individuals has focused on the creative person (Jalil & Boujettif, 2005; Shavinina, 2004; Zuckerman, 1967).

Studies on the creative process focus on the behavior of creativity and how creativity functions within individuals and the broader cultural domain (Runco, 2004). The creative process has been studied by researchers using “creativity tests” and tests of divergent thinking. Besides divergent thinking, however, other aspects of problem solving thought vital to the creative process have remained mostly unstudied. For instance, in addition to divergent thinking in the problem solving process, problem identification is thought to be equally important (Plucker & Renzulli, 1999).

Another category of creativity, the creative product, includes the outcomes of the creative process, such as a work of art or a scientific theory (Runco, 2004). Research on creative products emerged as a way to establish external criteria to creativity. This research has mainly focused on evaluating creative products using product ratings from external judges (such as experts, parents, and teachers) who usually judge products based on specific criteria (Plucker & Renzulli, 1999).

Last, the creative press includes studies concerned with the creative environment within which an individual operates, for example, a nurturing versus un-nurturing creative environment. The creative environment includes the individual, the discipline in which they work, the interaction between individuals in a given creative environment, the climate (attitudes within the creative environment), and the motivational forces driving an individual toward creativity. Many approaches that investigate the creative press/ creative environment investigate creativity using a “systems” approach (Plucker & Renzulli, 1999).

Studies on the creative process focus on the behavior of creativity and how creativity functions within individuals and the broader cultural domain (Runco, 2004). One such theory is

Csikszentmihalyi's systems approach (Runco, 2004). According to Csikszentmihalyi's systems approach to creativity, the creative individual is but one component of creativity (Csikszentmihalyi, 1996; Csikszentmihalyi, 1999). The systems approach postulates that there are three components to creativity: the domain, the field, and the individual (Csikszentmihalyi, 1996). A domain is the knowledge base that is made up of a set of symbolic rules and procedures (e.g. Physics), while a field includes the individuals who help maintain a given domain (e.g. journal editors, other physicists, etc.). In this approach, the creative individual seeks to add to and change a given domain, or create a new domain. The individual's idea, however, is only syndicated as creative when it is accepted by the gatekeepers of the field (Csikszentmihalyi, 1996).

Similar to the systems approach, Gardner and Nemirovsky's (1991) theory of creativity also emphasized an aspect of peer evaluation in establishing an idea as creative. Gardner and Nemirovsky theorized that there are three components of creativity which include: the cognitive talents exhibited by an individual; the structure of knowledge within a cultural domain; and the institutions and individuals who judge the quality of work within a domain. By using the cognitive processes and talents of the individual, creative ideas change the public symbol system, or knowledge that was already established. To demonstrate how the process of creativity occurs, Gardner and Nemirovsky (1991) investigated two case studies of eminent creative individuals; Georg Cantor and Sigmund Freud. Based on these two examples, the authors concluded that there are four main stages through which creative works pass.

First, the individual must have an intuition and develop their creative idea. Second, the individual must construct local coherences which provide a framework through which to discuss their creative idea with others in their field. Third, the individual must devise and revise the symbols that make up their idea, as well as redefine the ideas that already exist in their domain. Fourth, the individual must form a thema, or sense of how their theory fits with the worldview of their field. The majority of these steps deal with how an individual can incorporate their idea into an existing domain (Gardner & Nemirovsky, 1991). These steps are crucial in creating the possibility for a creative idea to be reviewed by individuals within a field, which in turn, can lead to the creative idea influencing an existing domain (Csikszentmihalyi, 1996).

The aspect of “peer review” of creative ideas is further emphasized by Gardner (1988) who theorized that it is cultural evaluation that separates merely novel creative ideas from important creative ideas. Therefore, a work can only be truly creative if it is deemed creative by others (Gardner, 1988). This element of cultural evaluation is also highlighted by Gruber’s (1988) evolving systems approach to creativity. Gruber suggested that a creative individual operates within a specific framework and that a real creative idea will serve to change this framework. Through this process of shaping the academic framework of a domain, human knowledge progresses and the creative individual builds on the work of his predecessors. This process is how progress occurs, and why scientific advancement must happen over a long period of time (Gruber, 1988). Similarly, Albert (1975) theorized that the acknowledgment of an individual’s genius occurs in three stages. First, the individual’s work is incorporated by others. Then, the individual’s genius is recognized by prestigious awards within their domain, such as the Nobel Prize. Last, the individual’s ideas are recognized throughout the lay public (Albert, 1975).

The domain in which creative ideas become accepted is continually being influenced by the *zeitgeist* at a given time (Boring, 1955; Runco, 2007). Boring (1955) described the *zeitgeist* phenomenon as the sum total of social interaction for a particular time period and a particular location. Therefore, the *zeitgeist* is merely the climate of opinion at a given time and place (Boring, 1955). While the *zeitgeist* is crucial to creativity, Boring (1955) warns that it can both help and hinder scientific advancement by creating communication within a field. The z*eitgeist* aids scientific creativity by directing scientists in the right direction, and providing a framework for other scientists to work from. However, the *Zeitgeist* can also create negative inertia within creative individuals. Inertia may make it difficult to remain original (Boring 1955). Creative inertia occurs when an individual's thought becomes slower due to the accumulation of new knowledge (Runco, 2007).

Creative Individuals

Apart from investigating the process of creativity, previous research has also investigated what it means to be a highly creative individual. Amabile's (1993) componential theory of creativity states that there are 3 components to a creative individual; domain-relevant skills, creativity-relevant skills, and intrinsic task motivation. Domain-relevant skills include the knowledge that an individual possesses that gives them talent within a domain. Creativity-relevant skills include the cognitive styles and specific personality style of the creative individual. Last, intrinsic task motivation is an individual's motivation to complete a task simply because the task is interesting, satisfying, or personally challenging to that individual (Amabile, 1993). The componential theory proposes that the combined interaction of an individual's domain-relevant skills, creativity-relevant skills, and intrinsic task motivation result in an individual's creativity.

Related to intrinsic task motivation, Simonton (1981) theorized that the intrinsic properties of creativity contribute to the observed historical pattern of productivity, where 'golden ages' are followed by 'dark ages'. Simonton believed this productivity pattern is due to the cluster of intrinsically motivated individuals in 'golden age' eras who tend to be more productive. Intrinsic motivation, however, is not the only type of motivation that may be crucial to creativity. Simonton concluded that both the intrinsic and extrinsic properties of creativity are important in driving creative individuals. While intrinsic motivation involves an individual being motivated by internal forces, extrinsic motivation implies the opposite. Extrinsic motivation occurs when an individual is motivated by the prospect of external gains such as money or fame. Extrinsic motivation is thought to be important to creativity as well (Amabile, 1983; Runco, 2007). The idea that both intrinsic and extrinsic properties are important to creativity who reiterated by Amabile (1983) who believed individuals are more likely to be creative if they are intrinsically motivated, but only to a certain point. After an individual passes a certain point of intrinsic motivation, extrinsic motivation enhances creativity by directing thinking towards a goal (Runco, 2007).

Since there are seemingly universal characteristics of creativity, some theorists believe that scientific innovation may be inevitable. The inevitability of scientific innovation is seen through the presence of duplicity in scientific innovation. Scientific duplicity occurs when an innovation is discovered around the same time by multiple individuals (Simonton, 1978). For example, the theory of evolution was independently proposed by both Darwin and Wallace. In response to the phenomenon of scientific duplicity, the social deterministic approach states that if an innovation had not been developed by the person we credit with developing it, the innovation would have been developed by someone else. Another approach, the "genius theory", poses the opposite explanation. The "genius theory" proposes that those who develop an innovation are unique in their genius (Simonton, 1978).

Simonton (1978) found that neither the social deterministic approach nor the “genius theory”, were endorsed when viewing innovation through the poisson model. The poisson model uses probabilities that specifically characterize rare events to determine the likelihood of independent discoveries. Simonton (1978) found that because creative discoveries have such a low probability of appearing, duplicity of independent discoveries cannot be evidence that scientific innovation is inevitable.

The function of chance and probability in scientific discovery is again emphasized by Simonton’s (1993) chance-configuration theory which suggests a possible framework under which idea formulation operates. The chance-configuration theory proposes that the mind can generate an infinite number of combinations of concepts, but that only some of these combinations will come together in a structural whole. When confronted with a problem, the creative mind has broader horizons that are able to look beyond what would normally be viewed as relevant. In this way, the creative individual is able to retrieve more associations, find more solutions, and look beyond a given domain (Simonton, 1993).

Albert (1975) also speculated that highly creative individuals possess special talents and cognitive abilities; however, he believed that creative individuals are only awarded the status of “genius” through the addition of their social efforts. The concept of genius has historically been mixed with aspects of both godliness and madness. In more recent times, genius has been judged on both an individual’s ability and what the individual does with that ability. Albert (1975) described Galton’s nineteenth century contributions to the study of genius as being key to the study of eminent creative individuals today. Galton proposed that an individual’s genius could be measured through a person’s eminence, reputation, and achievement. By suggesting that genius could be measured by factors external to an individual, Galton introduced the idea that an individual's genius was not inherent, but instead, culturally bound. Thus, it is up to the surrounding culture to determine whether an individual displays genius. Galton's theory also established that solidifying genius must occur over a long period of time, because only with time can reputation and eminence be developed (Galton, 1869; Albert, 1975).

Because the concept of "creative genius" is deeply rooted in public opinion, researchers have sought to better understand creativity through individuals who have distinguished themselves as eminent in their domain (Zuckerman, 1967; Cole, 1979). Albert (1975) supported the study of creative genius through eminent individuals by stating "One should look to persons of recognized eminence for genius, since genius is evidenced in a consensus of peers and is operationalized through the various reward procedures that every, society and profession has for acknowledging members' contributions" (pg. 143). Under similar assumptions, Nobel laureates have become a favorite population of study for researchers who seek to better understand creativity and genius (Jalil & Boujettif, 2005; Rothenberg, 1996; Shavinina, 2004; Zuckerman, 1967).

Nobel Laureates as Creative Individuals

Since 1901, the Nobel Prize has been awarded every year in various fields including chemistry, physics, and medicine (The Official Website of the Nobel Foundation, 2010). Winning this prestigious award represents the highest accomplishment an individual can achieve in a scientific discipline making Nobel laureates among the most creative individuals within our society (Zuckerman, 1967). Since Nobel laureates have been recognized as individuals at the forefront of scientific advancement, they have demonstrated an eminent level of creative ability (Zuckerman, 1967; Shavinina, 2004). Due to Nobel laureates' eminent level of ability, previous research has sought to better understand exactly what enables Nobel laureates to achieve at such a high creative level (Jalil & Boujettif, 2005; Rothenberg, 1996; Shavinina, 2004; Zuckerman, 1967). By studying highly creative individuals such as Nobel laureates, researchers have sought to better understand how creativity operates within creative individuals in general (Jalil & Boujettif, 2005).

Nobel laureates have been found to be more productive in that they begin publishing work earlier, publish more work than the average intellectual, and publish longer into their lives (Zuckerman, 1967). This finding is in contrast to the original belief that productivity and creativity decrease as one gets older (Cole, 1979). It has also been found that Nobel laureates oftentimes collaborate with other eminent individuals, and have the ability to adapt to working alone or in groups. These qualities of collaboration and adaptation are believed to contribute greatly to laureates winning the Nobel Prize (Zuckerman, 1967).

Shavinina (2004) found that Nobel Prize recipients may also possess extra-cognitive abilities which give them an especially high level of creative intellectual abilities. These extra-cognitive abilities include specific intellectually-creative feelings, specific intellectually-creative beliefs, specific preferences and intellectual values, and intuitive processes. These unique creative intellectual abilities may be the factors that allow Nobel laureates to develop their creative ideas (Shavinina, 2004).

Previous research has also investigated the personal historical and demographic characteristics of Nobel laureates. Research by Charyton, Woodard, Rahman, and Elliott (2010), investigated the personal history of all Nobel Prize winners in physics, chemistry, and medicine since 2006. Data on aspects of the Nobel laureates' personal history, such a country of award, percent of prize allocation, marital status, number of children, family background, birth order, education background, occupation, and number of total publications were collected. Their results indicate that laureates' were awarded the prize earlier when they (1) had more allocation of credit, (2) had post-doctoral first positions, and (3) earned prizes in physics. However, laureates' awarded prizes in North America, Central America, and South America received the prize significantly later. Contrary to previous literature, factors such as gender and birth order did not play significant roles in earning the Nobel Prize at an earlier age (Charyton et al., 2010). Similarly, gender of Nobel Prize winners since 2006 in physics, chemistry, and medicine has also been investigated. Female Nobel laureates were found to be less likely to marry and have children, and also produced fewer publications than male Nobel laureates (Charyton, Elliott, Rahman, Woodard, & DeDios, 2010).

Measures of Scientific Productivity

Objective measures of academic influence such as citation count, journal impact factor, journal cited half-life, and Eigenfactor score have been used to evaluate journal quality and individual proliferation. Measures of academic influence play an important role in the distribution of government research funds, research grant funding, and academic tenure track positions (Crisp, 2009; Garfield, 1955; Garfield, 2005; Roediger, 2010). Some creativity theorists have proposed that these measures be included in creativity studies of individuals as well (Gardner, 1988). Gardner (1988) reflects this view by saying "A science of creativity propounds the laws which govern the behaviors and thought processes of such individuals and the principles by which certain products come to be judged as creative; such a science also seeks to quantify creativity with measures like citation counts, expert's ratings, or indices of impact within a discipline or a culture" (pg. 9).

Because journal publications represent the major way in which scientific research findings are disseminated, it is natural to look to measures of article and journal quality to deduct the perceived importance and acceptance of scientific ideas (Magri & Solari, 1996). In the present study, creative idea acceptance is quantified through such measures.

Publication Citation Count. Publication citation count reflects how well-known a given paper is among the scientific community. Therefore, citation count helps indicate the influence of a given paper. Papers that have high citation counts are presumed to contain “important research”. The presumed importance that accompanies highly cited papers greatly contributes to their future popularity, and thus, allows them to accumulate even more citations (Hsu & Huang, 2011). For the purposes of this study, citation count directly indicates how accepted a creative idea is within a field, with higher citation counts indicating higher levels of acceptance.

Journal Impact Factor. Journal impact factor was developed in 1963 as a measure of importance or influence based on citation count for a given time period for a specific journal. By definition, journal impact factor is a journal’s number of citations in a given year divided by the total number of articles that were published in that journal in the previous two years. Although journal impact factor should not be taken to reflect the quality of individual articles within a journal, journal impact factor is an accepted measure of how prestigious a journal is in the academic world (Coleman, 2007). If a journal has a high impact factor, then articles in that journal are being highly cited by other publications. This generally makes the journal more influential and prestigious (Citrome, 2007; Garfield, 2005). Journals containing articles that are not widely cited, however, have low impact factors. Therefore, a low impact factor usually indicates that a journal is also low in influence and prestige (Citrome, 2007; Garfield, 2005). Since journals with high impact factors are generally the most prominent, submissions for publication are more likely to be rejected in these journals. While being published in a journal with a high impact factor is not necessarily synonymous with producing a high quality article, being published in a high impact journal at least demonstrates that the content of the author's idea was worthy of being published in a prestigious journal. Therefore, journal impact factor has become a key way in which academic and research professionals are evaluated (Garfield, 2005).

Journal impact factor, however, has been criticized as a skewed measure of journal influence because it can be greatly swayed by a few atypical, highly cited papers (Roediger, 2010). Other measures, such as 5-year journal impact factor, citation count, journal cited half-life, and journal immediacy index have been used as measures to supplement the 2-year journal impact factor (Cole, 2007).

Journal Cited Half-Life. Journal cited half-life attempts to account for the recency of citations, by providing a median age of articles in a given journal for a given year (Thompson Reuters, 2011a). However, journal cited half-life, like other journal-quality assessment measures based on citation rate, is not without its drawbacks. Similar to other citation rate based measures (i.e. citation count, journal impact factor), cited half-life does not take into account the quality of the citing journals or the field of research within which a given journal exists (Crisp, 2009).

Eigenfactor Score. Eigenfactor score, developed by Carl Bergstrom, attempts to eliminate the drawbacks of other journal quality measures, by taking into account the relative influence of a given journal within a field of research. Eigenfactor score addresses citing journal quality by assigning journals an "importance" weight that weights the citations received by that journal. Eigenfactor also addresses the field of research within which a journal exists by creating networks of journal citations (Crisp, 2009). Therefore, by weighting a score similar to impact factor by discipline, Eigenfactor score specifically seeks to address the "total importance of a scientific journal" (Roediger, 2010).

Although many creativity theories have suggested ways in which creative ideas transition from the creative individual to being integrated into a system of knowledge, this process has not been demonstrated empirically, though it has been called for from leading creativity theorists (Gardner, 1988). Despite the need for more quantitative research concerning creativity, from the 1970s to the present day creativity research has predominantly followed the post-positivist tradition of using qualitative approaches to study creativity (Jalil & Boujettif, 2005). Our study, seeks to use quantitative measures to investigate creativity, rather than the more traditional qualitative approaches.

Furthermore, it is important to address the question of how creative ideas become accepted theoretically as well as empirically because creative ideas are known to be accompanied by a level of deviance due to their originality (Runco, 2004). This invariably makes creative ideas riskier. Because creative ideas are characteristically defined by a high level of novelty, they inevitably are accompanied by risk (Runco, 2007). This risk is related to the fact that creative ideas are untested and are sometimes contradictory to what is already known about a subject. While a creative idea may answer questions, it may also create new ones to be answered (Gardner & Nemirovsky, 1991). Therefore, because acceptance from a given field determines what ideas are viewed as creative, creative idea acceptance is as important as the creative idea itself (Gardner, 1988).

The Present Study

In the present study, we sought to use quantitative measures to evaluate how accepted the Nobel laureates' Nobel ideas were throughout time. Based on previous literature, we theorized that overall Nobel idea acceptance takes time. This theory provided the basis for the three main hypotheses (A-C) for this study.

We hypothesized (A) that when the laureates' first published their Nobel ideas, their ideas were not widely accepted by their field; as evidenced by the laureates' 'first Nobel idea' publications (FN) having significantly lower citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores than the laureates' 'highest cited Nobel idea' publications (HN).

We also hypothesized (B) that the Nobel laureates 'highest cited Nobel idea' publications would be more accepted than both their 'first Nobel idea' publications and their 'last Nobel idea' publications; as evidenced by the laureates' 'highest cited Nobel idea' publications (HN) having significantly higher publication citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores than the laureates' 'first Nobel idea' publications (FN) and 'last Nobel idea' publications (LN).

Last, we hypothesized (C) that the Nobel laureates' 'first Nobel idea' publications would be less accepted than the laureates' 'last Nobel idea' publications; as evidenced by the laureates' 'first Nobel idea' publications (FN) having significantly lower citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores than the laureates' 'last Nobel idea' publications (LN). Combined, we predicted from hypotheses (A-C) that idea acceptance would follow FN < LN < HN (with HN being the most accepted Nobel idea publication).

Method

Population

One hundred and eighty-seven Nobel Prize winners from 1980- 2009 in chemistry (N = 65), physics (N = 59), and medicine/ physiology (N = 63) were studied. All data were collected using the ISI Web of Science (ISI), the Journal Citation Reports (JCR), eigenfactor.org, nobelprize.org, Inspec Historical, Compendex, and PubMed. All of these resources were available free to undergraduate students through The Ohio State University library system. Therefore, no participants were required to consent to participate in this study, and the project was IRB exempt. Only 187 out of the possible 204 laureates from 1980-2009 were included in this analysis due missing data from the ISI Web of Science. These laureates were excluded mostly due to the way ISI requires names to be input (last name, first initial, additional initials). ISI's author input system makes it difficult for many foreign and hyphenated (ex: Pierre-Gilles de Gennes and Rita Levi- Montalcini) names to yield accurate results. Because we could not be sure that we were capturing data for the correct author name, these laureates were excluded from analysis. Additionally, Nobel laureates from 1901 to 1979 were excluded from this analysis due to the lack of past data available for these individuals.

The laureates included in this analysis were between the current ages/ ages at death of 46 to 98 years old at the time of collection, and were between the ages of 37 to 88 years old when they were awarded their Nobel Prize. Demographically, approximately 97% of the laureates studied were male and 3% were female. The laureates studied represented a diverse international population with 52% from the Americas, 7% from Asia, 4% from Eastern Europe, 28% from Western Europe, 4% from Northern Europe, 3% from Australia, and 2% from other geographic areas.

Measures

Data were collected for three publications in the Nobel laureates' careers; 'first Nobel idea' publication (FN), 'highest cited Nobel idea' publication (HN), and 'last Nobel idea' publication (LN). Idea acceptance was evaluated for each of these publications using measures of 'prestige' for the individual publications, and measures of prestige for the journals in which these publications appeared. The journal name and year of publication were recorded for each publication.

Measure for Individual Publications. The 2010 publication total citation count was collected for each publication (FN, HN, and LN). These total citation counts were recorded according to what was listed on the ISI Web of Science.

Journal of publication measures. Data for 7 variables that measured the prestige of the journals that the individual publications were published in were collected for each publication (FN, HN, and LN). Among these variables were (1) the 2009 five year journal impact factor, (2) the 2009 journal impact factor, (3) the journal impact factor for the publication year, (4) the 2009 journal immediacy index, (5) the 2009 journal cited half-life, (6) the 2008 journal Eigenfactor score, and (7) the 2008 journal article influence score. All variables were rounded to two decimal points with the exception of Eigenfactor score which was rounded to 4 decimal points. The data for the ‘journal of publication’ measures were recorded according to what was listed on the Journal Citation Reports and eigenfactor.org.

Procedure

All variables were collected for each Nobel laureate using nobelprize.org and three additional databases; the ISI Citation Database (1965-2010), Journal Citation Reports (JCR), and eigenfactor.org. Data for the Nobel laureate’s individual publication citations were all collected using the ISI Citation Database. In the author search line of ISI, the last name and all initials for each laureate were input. For example, Jack W. Szostak was input as Szostak JW. If no initials were given for the Nobel laureates on nobelprize.org, then no initials were included for that laureate on ISI. For example, Oliver Smithies was input as Smithies O.

In addition to inputting the laureate's name in the author line, keywords from the laureates' Nobel ideas (as described on nobelprize.org) were included in the topic line. For example, Jack W. Szostak's Nobel idea was listed as "the discovery of how chromosomes are protected by telomeres and the enzyme telomerase" (Nobelprize.org, 2010). Our keyword for this laureate was "telomeres" (see Table A1 for a complete list of laureates, Nobel ideas, and Nobel idea keywords).

After our author and topic lines were completed we selected "search", and ISI would generate all publication results that included our author name and topic. We then selected the "create citation report" option which generated information on all of the selected laureate's publications. This report provided the total number of publications concerning the selected laureate's Nobel idea, as well as the total number of citations concerning the selected laureate's Nobel idea. The report ISI generated also provided the publication title, journal of publication title, publication year, and total citation count for each of the selected laureate's publications of interest (FN, HN, and LN).

Information on the journals that these publications (FN, HN, and LN) were published in, was then collected using the Journal Citation Reports (JCR). The JCR provided data for all the journal measures (the five year journal impact factor for 2009, the two year journal impact factor for 2009, the two year journal impact factor for the year of the publication, the immediacy index for 2009, and the cited half-life for 2009), except for Eigenfactor score and article influence score.

The 2008 Eigenfactor scores and article influence scores for each journal of publication were collected using eigenfactor.org. On eigenfactor.org the journal of publication was input for each publication of interest (FN, HN, and LN). The journal of publication was then selected from a generated list. Eigenfactor.org would then create a report for the journal of publication that included the journal's Eigenfactor score and article influence score.

For each publication (FN, HN, and LN) all collected data was stored electronically.

Selected Instruments

Based on preliminary correlation data, we selected to analyze four measures of scientific creative idea acceptance.

1) 2010 Total Publication Citation Count. The 2010 total publication citation count reflects the total number of times the publications of interest (FN, HN, and LN) have been cited by other publications as of 2010 as recorded by ISI. The most recent publication citation count upon data collection was used.

2) 2009 Journal Impact Factor. The 2009 journal impact factor concerns the journals in which the publications of interest (FN, HN, and LN) were published. Journal impact factor is calculated by dividing the number of citations in a given year (2009) by the total number of articles that were published in the previous two years. For example, an Impact Factor of 7.00 indicates that on average articles published one to two years ago in the given journal have been cited seven times. Although citing articles can be from the same journal, generally they are not (Thompson Reuters, 2011a). Generally, journals with higher journal impact factors are thought to be more prestigious, and therefore, contain articles that are more widely read within a given discipline. The 2009 journal impact factor was used for this analysis because it was the most recent journal impact factor available upon collection, and therefore, was available for the largest sample.

3) 2009 Journal Cited Half-life. The 2009 journal half-life concerns the journals in which the publications of interest (FN, HN, and LN) were published. The journal half-life is meant to represent the median age of articles that were cited in a given journal for a given year (2009). For example, if a journal has a cited half-life of 7.0 for 2009, this indicates that articles published in that journal between 2003-2009 account for 50% of all citations to articles in that journal for 2009. However, only journals that are cited 100 times or more in a given year have a cited half-life in the JCR (Thompson Reuters, 2011a). Although a higher journal cited half-life is not synonymous with higher journal quality, in this study, a higher half-life seemed to accompany the more prestigious journals. The 2009 journal cited half-life was used for this analysis because it was the most recent cited half-life score available upon collection, and therefore, was available for the largest sample.

4) 2008 Journal Eigenfactor Score. The 2008 journal Eigenfactor score concerns the journals in which the publications of interest (FN, HN, and LN) were published. Eigenfactor score is based on the number of times articles published in the past five years from a given journal are cited in a given year (2009). Eigenfactor score takes into account which journals have contributed citations, resulting in more highly citing journals influencing the journal network more than lesser citing journals (Thompson Reuters, 2011a). In this way, the Eigenfactor algorithm takes into account the fact that different disciplines generally publish in different journals. By weighting journals based on what journal network they belong, Eigenfactor attempts to decrease the impact factor disparity between disciplines. The journal network is determined by an algorithm using a vast network of citations to evaluate the importance of the journal (Thompson Reuters, 2011b). The 2008 Eigenfactor score was used for this analysis because it was the most recent Eigenfactor score available upon collection.

Results

Table 1 displays the descriptive statistics (mean and standard deviation) for our four measures of creative idea acceptance: (1) 2010 publication citation count, (2) 2009 journal impact factor, (3) 2009 journal cited half-life, and (4) 2008 Eigenfactor score.

Correlation Results

A two-tailed bivariate correlation demonstrated the relationship between our measures of scientific acceptance (2010 publication citation count, 2009 five year journal impact factor, 2009 journal impact factor, journal impact factor for the year of the publication, 2009 journal immediacy index, 2009 journal cited half-life, 2008 Eigenfactor Score, and 2008 article influence score), as shown in Tables 2.1, 2.2, and 2.3, indicating a strong positive relationship between the measures of acceptance. We found that for each publication of interest (FN, HN, and LN) there were high correlations between 2009 journal impact factor and journal impact factor for the year of the publication (FN: $r = .91$, HN: $r = .80$, LN: $r = .99$, $p < .01$); between 2009 journal impact factor and 2009 5 year journal impact factor (FN: $r = 1.00$, HN: $r = .97$, LN: $r = .56$, $p < .01$); between 2009 journal impact factor and 2009 journal immediacy index (FN: $r = .92$, HN: $r = .83$, LN: $r = .87$, $p < .01$); and between 2009 journal impact factor and 2008 article influence score (FN: $r = .98$, HN: $r = .92$, LN: $r = .96$, $p < .01$). Due to the highly correlated data for the aforementioned measures of acceptance, these measures were excluded from analyses. Instead the 2009 journal impact factor data were analyzed. Although 2010 publication citation count, 2008 journal half-life, and 2008 Eigenfactor score were somewhat correlated to 2009 journal impact factor, due to the fact that all of these measures use citation counts in some way to derive their influence values, these correlation coefficients were not high enough to exclude these measures from analysis. Therefore, the acceptance measures selected for further analyses were 2010 publication citation count, 2009 journal impact factor, 2008 journal half-life, and 2008 Eigenfactor score.

Main Analysis

We used a 3 x 3 repeated measures ANOVA (publication of interest [FN, HN, LN] x prize area [physics, chemistry, medicine]) to assess (1) 2010 publication total citation count, (2) 2009 journal impact factor, (3) 2009 journal cited half-life, and (4) 2008 journal Eigenfactor score.

1) 2010 Publication Total Citation Count. A repeated measures ANOVA was conducted. Homogeneity was not met; therefore Greenhouse-Geisser analyses were performed. There was a significant main effect of publication of interest for citation count *MSE* (1417543.53), F (2, 366) = 71.74, p < .001. See Figure 3 for graph. There was no significant main effect of prize are for citation count *MSE* (2897086.59), F (2, 183) = 1.71, p > *.15*. There was no significant interaction effect between publication of interest and prize area for citation count *MSE* (1417543.53), F (4, 366) = 1.46, p > .05. To follow up on the statistically significant main effect, we performed a paired t-test. There were significant differences between all publications (FN, HN, and LN): FN and HN [t (-8.1), df (185), p < .001]; HN and LN [t (9.76), *df* (185), p < .001]; and FN and LN [t (4.63), *df* (185), p < .001].

2) 2009 Journal Impact Factor. A repeated measures ANOVA was conducted. Homogeneity was not met; therefore Greenhouse-Geisser analyses were performed. There was a significant main effect of publication of interest for impact factor *MSE* (95.05), F (2, 240) = 23.36, p < .001. There was a significant main effect of prize area for impact factor *MSE* (169.12), F (2, 120) = 19.06, p < .001. There was also a significant interaction effect between publication of interest and prize area for impact factor *MSE* (95.05), F (4, 240) = 6.11, p < .001.

See Figure 4 for graph. We performed a Tukey posthoc analysis and found significant results for physics ($p < .001$). To follow up on the statistically significant main effect, we performed a paired T-test. There were significant differences between all publications (FN, HN, and LN): FN and HN [t (-4.95), df (135), $p < .001$]; HN and LN [t (7.03), df (152), $p < .001$]; and FN and LN [t (2.32), df (129), $p < .001$].

To follow up on the significant interaction effect we conducted a Brown-Forsythe one-way ANOVA for the FN and HN. With the one-way ANOVA we found significant findings for FN: F (2, 140) = 13.72, $p<.001$. Then using a Tukey posthoc analysis for FN, we also found significant differences between all disciplines: physics and medicine ($p < .001$), physics and chemistry ($p < .05$), and chemistry and medicine ($p < .05$). With the one-way ANOVA we also found a significant findings for HN: F (2, 169) = 24.54, $p < .001$. Then using a Tukey posthoc analysis for HN, we also found significant differences between physics and medicine ($p < .001$), and physics and chemistry ($p < .001$). There were no significant differences between chemistry and medicine ($p >.05$) for HN. Since homogeneity was met for LN, a two-way ANOVA was performed, however, there were no significant differences between disciplines for LN: F (2, 163) = 1.56, $p > .05$.

3) 2009 Journal Cited Half-life. A repeated measures ANOVA was conducted. Homogeneity was not met; therefore Greenhouse-Geisser analyses were performed. There was a significant main effect of publication of interest for half-life *MSE* (1.79), F (2, 234) = 27.50, $p < .001$. There was no significant main effect of prize area for half-life *MSE* (2.42), F (2, 117) = 1.00, $p > .15$. There was also a significant interaction effect between publication of interest and prize area for half-life *MSE* (1.79), F (4, 234) = 3.09, $p < .05$. See Figure 5 for graph. We performed a Tukey posthoc analysis, but did not find any significant results for prize area (p > .05).

To follow-up on the significant interaction effect, we conducted a paired T-test for prize area (physics, chemistry, and medicine). For physics, we found no significant differences between the publications of interest (FN, HN, and LN) ($p > .05$). For chemistry, we found significant differences between HN and LN [t (5.28), df (49), $p < .001$], and FN and LN [t (4.66), df (42), $p < .001$]. There were no significant differences between FN and HN ($p > .05$) for chemistry. For medicine, again we found significant differences between HN and LN [t (6.23), df (51), $p < .001$], and FN and LN [t (4.24), df (42), $p < .001$]. There were no significant differences between FN and HN ($p > .05$) for medicine.

4) 2008 Journal Eigenfactor score. A repeated measures ANOVA was conducted. Homogeneity was not met; therefore Greenhouse-Geisser analyses were performed. There was a significant main effect of publication of interest for Eigenfactor score MSE (0.32), F (2, 244) = 12.14, $p < .001$. See Figure 6 for graph. There was no significant main effect of prize area for Eigenfactor score MSE (0.59), F (2, 122) = 0.13, $p > .15$. There was no significant interaction effect between Eigenfactor score and prize area MSE (0.32), F (4, 244) = 0.49, $p > .05$. To follow up on the statistically significant main effect, we performed a paired T-test. There were significant differences between HN and LN [t (4.9), df (157), $p < .001$], and FN and LN [t (3.38), df (128), $p = .001$]. There were no significant differences between FN and HN [t (-1.6), df (139), $p>.05$].

Discussion

In this study we investigated creative idea acceptance for Nobel laureates by tracking acceptance for three key publications in the Nobel laureates' careers; 'first Nobel idea' publication (FN), 'highest cited Nobel idea' publication (HN), and 'last Nobel idea' publication (LN). Based on the broad theory that creative idea acceptance occurs over time, we developed three main hypotheses. Hypothesis (A) was supported in that HN had higher levels of acceptance than FN; however this was not always to a statistically significant amount. For 2009 journal cited half-life and 2008 Eigenfactor score, HN and FN were statistically equal in acceptance. Hypothesis (B) was supported in that HN was the most highly accepted publication when using some measures of acceptance; however, for other measures of acceptance HN and FN were statistically equal in acceptance. Hypothesis (C) was not supported in that FN was never less accepted than LN, with the exception of one unique case. Overall, through our hypotheses we predicted that acceptance for the laureates' Nobel publications would follow the pattern of FN < LN < HN (with HN having the highest level of acceptance). Instead, we found that idea acceptance generally followed the acceptance pattern of LN < FN < HN.

Hypothesis (A)

At the beginning of the study, we hypothesized (A) that the Nobel laureates 'first Nobel idea' publications (FN) would be less accepted than the Nobel laureates' 'highest cited Nobel idea' publications (HN). We predicted that this would be evidenced by FN having lower publication total citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores than HN. Overall, our results in regards to hypothesis (A) imply that FN was less accepted than HN, however on some measures of acceptance, HN and FN were not statistically different. Therefore, hypothesis (A) was only supported for 2010 publication total citation count and 2009 journal impact factor.

Hypothesis (A): 2010 Publication Total Citation Count. For 2010 publication total citation count, we found that FN and HN were significantly different from each other, with FN having significantly lower publication citation counts than HN. Therefore, hypothesis (A) was supported, and FN was found to be less accepted than HN for publication total citation count. There were no significant differences between prize areas for FN and HN for publication total citation count.

Hypothesis (A): 2009 Journal Impact Factor. For 2009 journal impact factor, we found that FN and HN were again significantly different from each other, with FN having significantly lower journal impact factors than HN. Therefore, hypothesis (A) was supported, and FN was found to be less accepted than HN for journal impact factor. There were no significant differences between prize areas for FN and HN for journal impact factor.

Hypothesis (A): 2009 Journal Cited Half-life. For 2009 journal cited half-life, we found that the mean FN half-life ratings were less than the mean HN half-life ratings. However, FN and HN half-life ratings were statistically equal. Therefore, hypothesis (A) was not supported statistically, and FN and HN were relatively equal on level of acceptance for journal cited half-life. There were no significant differences between prize areas for FN and HN for journal impact factor.

Hypothesis (A): 2008 Eigenfactor Score. For 2008 journal Eigenfactor score, we found that the mean FN Eigenfactor scores were less than the mean HN Eigenfactor scores. However, like journal cited half-life, FN and HN Eigenfactor scores were statistically equal. Therefore, hypothesis (A) was not supported statistically, and FN and HN were relatively equal on level of acceptance for Eigenfactor score. This finding was consistent across all prize areas.

Hypothesis (B)

At the beginning of the study, we hypothesized (B) that the Nobel laureates ‘highest cited Nobel idea’ publications (HN) would be more accepted than both their ‘first Nobel idea’ publications (FN) and their 'last Nobel idea' publications (LN). We predicted that this would be evidenced by HN having significantly higher publication total citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores than both FN and LN. Overall, our results in regards to hypothesis (B) imply that HN was the most highly accepted of the Nobel publications under investigation, however on some measures of acceptance, HN and FN were not statistically different. Therefore, hypothesis (B) was only supported when using 2010 publication total citation count and 2009 journal impact factor.

Hypothesis (B): 2010 Publication Total Citation Count. For 2010 publication total citation count, we found that HN was significantly different from both FN and LN, with HN having significantly higher citation counts than both FN and LN. Therefore, hypothesis (B) was supported, and HN was more accepted than both FN and LN for citation count. There were no significant differences between prize areas for FN, HN, and LN for citation count.

Hypothesis (B): 2009 Journal Impact Factor. For 2009 journal impact factor, we found that HN was significantly different from both FN and LN, with HN having significantly higher journal impact factors. Therefore, hypothesis (B) was supported, and HN was more accepted than both FN and LN for journal impact factor. There were no significant differences between prize areas for FN, HN, and LN for journal impact factor.

Hypothesis (B): 2009 Journal Cited Half-life. For 2009 journal cited half-life, we found that the mean half-life ratings of HN were greater than the mean half-life ratings of both FN and LN. However, the significance of these differences between HN, FN, and LN, varied by prize area. In chemistry and medicine, the half-life ratings of HN were significantly more than the half-life ratings of LN, but the half-life ratings of HN and FN were statistically equal. Therefore, hypothesis (B) was not supported statistically in chemistry and medicine, and HN was only statistically more accepted than LN for journal cited half-life. In physics, the half-life ratings of HN, LN, and FN were all statistically equal. Therefore, hypothesis (B) was also not supported statistically in physics, and all publications were statistically equal in acceptance for journal cited half-life.

Hypothesis (B): 2008 Eigenfactor Score. For 2008 journal Eigenfactor score, we found that the mean Eigenfactor scores for HN were higher than the mean Eigenfactor scores for FN and LN. However, while Eigenfactor scores for HN were significantly higher than Eigenfactor scores for LN, Eigenfactor scores for HN and FN were statistically equal. Therefore, hypothesis (B) was not supported, and HN was only statistically more accepted than LN for Eigenfactor score. There were no significant differences between prize areas for FN, HN, and LN for Eigenfactor score.

Hypothesis (C)

At the beginning of the study, we hypothesized (C) that the Nobel laureates' 'first Nobel idea' publications (FN) would be less accepted than the laureates' 'last Nobel idea' publications (LN). We predicted that this would be evidenced by FN having significantly lower publication total citation counts, journal impact factors, journal cited half-life ratings, and Eigenfactor scores than LN. Overall, our results imply the opposite pattern of acceptance, in that FN was almost always more accepted than LN for our measures of acceptance. Therefore, hypothesis (C) was not supported, with the exception of the unique case of physics for journal impact factor.

Hypothesis (C): 2010 Publication Total Citation Count. For 2010 publication total citation count, we found that FN and LN were significantly different in citation count, with FN having significantly higher citation counts than LN. This pattern of acceptance was opposite of the predicted pattern. Therefore, hypothesis (C) was not supported, and FN was more accepted than LN for citation count. There were no significant differences between prize areas for FN and LN for citation count.

Hypothesis (C): 2009 Journal Impact Factor. For 2009 journal impact factor, we found that FN and LN were significantly different in citation count. The nature of these differences, however, varied by prize area. In chemistry and medicine, FN had significantly higher journal impact factors than LN. This pattern of acceptance was opposite of the predicted pattern. Therefore, hypothesis (C) was not supported in chemistry and medicine, and FN was more accepted than LN for journal impact factor. In physics though, FN had significantly lower journal impact factors than LN. This was the only case where the predicted pattern of acceptance was observed. Therefore, hypothesis (C) was supported in physics, and FN was less accepted than LN for journal impact factor.

Hypothesis (C): 2009 Journal Cited Half-life. For 2009 journal cited half-life, we found that the mean cited half-life ratings of FN were higher than the mean cited half-life ratings of LN. However, the significance of this difference between FN and LN varied by prize area. In chemistry and medicine, FN had significantly higher half-life ratings than LN. This was opposite of the predicted pattern of acceptance. Therefore, hypothesis (C) was not supported in chemistry and medicine, and FN was more accepted than LN for cited half-life. In physics though, half-life ratings for FN and LN were statistically equal. Therefore, hypothesis (C) was also not supported in physics, and FN and LN were statistically equal in acceptance for cited half-life.

Hypothesis (C): 2008 Eigenfactor Score. For 2008 Eigenfactor score, we found that FN had significantly different Eigenfactor scores than LN, with FN having significantly higher Eigenfactor scores than LN. This was opposite of the predicted pattern of acceptance. Therefore, hypothesis (C) was not supported, and FN was more accepted than LN for Eigenfactor score. There were no significant differences between prize areas for FN and LN for Eigenfactor score.

Overall Findings from Hypotheses

Overall, our predicted pattern of idea acceptance of FN < LN < HN (with HN representing the most accepted Nobel idea publication), was not found. Instead, idea acceptance followed the pattern of LN < FN < HN, with HN only statistically more accepted than FN for publication total citation count and journal impact factor.

One potential explanation for why LN was less accepted than FN may be that LN somehow diverged from the laureates' original prize winning idea. Through LN's divergence, LN may have become more novel than FN. Because idea acceptance occurs over a long period time (the Nobel laureates in this sample were awarded the Nobel Prize at an average of 62.12 years of age), it is likely that the laureates would have expanded their original Nobel ideas. If the contents of LN do represent a more expanded form of the laureates' original Nobel idea, it is possible that the ideas presented in LN could diverge enough to become novel, and therefore, not presently accepted. This possible explanation, however, is merely a speculation. More research is needed in order to examine whether LN is diverging from the laureates' original prize winning idea.

Other Key Findings: Physics Compared to Chemistry and Medicine

One key finding that we did not anticipate was the effect of prize area on idea acceptance. We found that the acceptance pattern for the Nobel publications in physics, were significantly different from acceptance pattern for the Nobel publications in chemistry and medicine, when using 2009 journal impact factor and 2009 journal cited half-life to measure acceptance. However, we found no significant differences between the acceptance patterns for the Nobel publications in physics, chemistry, or medicine, when using 2010 publication total citation count and Eigenfactor score to measure acceptance.

Physics: Differences in 2009 Journal Impact Factor. For 2009 journal impact factor, we found that physics was significantly different from both chemistry and medicine, with physics having significantly lower journal impact factors than both chemistry and medicine. Chemistry and medicine were statistically equal in journal impact factor. In physics we also found a significantly different overall pattern of Nobel idea acceptance, than in chemistry and medicine when using journal impact factor to measure acceptance. In both chemistry and medicine, FN, HN, and LN were all significantly different from each other, with journal impact factor ordered lowest to highest as LN < FN< HN. Therefore, Nobel idea acceptance in chemistry and medicine followed the ordered acceptance pattern of LN < FN < HN for 2009 journal impact factor. For physics, however, FN, HN, and LN were all significantly from each other with journal impact factor ordered lowest to highest as FN < LN < HN. Therefore, Nobel idea acceptance in physics followed the ordered acceptance pattern of LN < FN < HN for 2009 journal impact factor.

Physics: Differences in 2009 Journal Cited Half-life. For 2009 journal half-life, physics again followed a significantly different pattern of idea acceptance than both chemistry and medicine. In chemistry and medicine, LN had significantly lower journal cited half-life ratings than both FN and HN. Therefore in chemistry and medicine, LN was significantly less accepted than both FN and HN for 2009 journal cited half-life. In physics, however, FN, HN, and LN were statistically equal in journal cited half-life ratings. Therefore in physics, FN, HN, and LN are statistically equal in acceptance for 2009 journal cited half-life.

Overall Differences in Physics from Chemistry and Medicine. Overall, the irregular patterns of acceptance that we observed for physics when using 2009 journal impact factor and 2009 journal cited half-life, indicate that creative idea acceptance may occur differently in the domain of physics than the domains of chemistry or medicine. When considering journal cited half-life, the acceptance of Nobel idea publications in physics seems to be relatively stable over time. While other measures of acceptance, indicate that acceptance still varies to a significant amount across the three Nobel idea publications. Because physics only appeared different on measures of journal influence (2009 journal impact factor and 2009 journal cited half-life), it is possible that differences in physics may be caused differences between journals in physics from journals in chemistry and medicine. This is supported by our findings for 2009 journal impact factor, where journals in the domain of physics were significantly lower in impact factor than journals in the domains of chemistry or medicine.

One possible explanation for why physics journals may be different from journals in chemistry or medicine is that journals in the disciplines of chemistry and medicine may tend to overlap. If topics in chemistry and medicine overlap more than topics in physics and chemistry, or physics and medicine, scientists in chemistry and medicine may publish in more similar journals. A potential overlap in chemistry and medicine could cause Nobel laureates' from chemistry and medicine to publish in many of the same journals. This would result in the Nobel laureates' from chemistry and medicine having more similar 2009 journal impact factors and 2009 journal cited half-life ratings. Therefore, common journals could help account for the observed differences in journal influence across prize areas.

Another possible explanation for journal differences in physics may be that physics journals are generally more domain-specified than journals in chemistry and medicine. Domain-specific journals generally have lower impact factors and cited half-life ratings because they are almost exclusively read by individuals within a specific domain (Roediger, 2010). Among the highest impact journals are journals such as *Nature* or *Science* which represent more general scientific journals.

Overall, more research is needed to explain why Nobel idea acceptance is different in physics than in chemistry and medicine. However, our findings provide evidence that creative idea acceptance in general may occur differently across disciplines. It is also important to note that academic influence can vary by discipline for certain measures of academic influence. As seen in our findings concerning physics, not all disciplines have similar levels of academic influence. Therefore, when making important academic decisions based on influence measures such as impact factor or journal cited half-life, different disciplines should ideally be evaluated differently.

Limitations and Future Directions

This study was somewhat limited in a few key areas. In relation to 2010 publication total citation count, LN may have appeared to be significantly lower in citation count due to a recency-effect. Since most of the LN publications were from 2000-2009, these publications would not have had as much of an opportunity to be cited. Therefore, LN could have been low in citation count merely because it was released so recently. We do not believe that there were recency-effects for our other measures of acceptance (2009 journal impact factor, 2009 journal cited half-life, and 2008 Eigenfactor score), because as seen in our correlation results, measures of journal influence remain fairly stable over time (see Tables 2.1, 2.2, and 2.3 for full correlation results). These other measures of acceptance (2009 journal impact factor, 2009 journal cited half-life, and 2008 Eigenfactor score), mostly displayed the same pattern of idea acceptance as 2010 publication citation count. Therefore, it is hard to determine if a recency-effect for citation count accounted for the outcome of our results. Future research could seek to minimize the chance of a recency-effect by using an equalizing measure of citation count, such as citations per year.

Another limitation of this study was in reference to the method through which data were collected. FN, HN, and LN were all determined using the ISI Web of Science. Therefore, if a publication was not input into the ISI archives, it would not be included in our analysis. Furthermore, ISI only archives data on publications released from 1965-2009. The unavailability of information before 1965 may have confounded FN in that it is possible that FN may not represent the actual first Nobel idea for some cases. This would be more of a problem for Nobel laureates who were farther in the past (closer to 1980). These limitations of the ISI database were addressed in this study by cross referencing ISI's search results with other academic databases, such as Inspec Historical, Compendex, and PubMed. By cross referencing our search results, we were able to check if ISI yielded an accurate FN publication. Although this check provided additional assurance that we had collected the correct FN publication, in some situations more expertise in the prize areas (physics, chemistry, and medicine) was needed in order to detect if the cross referencing results were indeed concerning the laureates' Nobel ideas.

Another limitation of this study, concerns the conclusions that we were able to draw about the complete process of creative idea acceptance in Nobel laureates. Since we collected data on only three time periods of the laureates' publishing career (FN, HN, and LN), we can only speculate about what is occurring between each of these publications. Despite this limitation, no other studies to date have investigated the acceptance levels of Nobel laureates' Nobel idea publications over time. This study still provides an important starting point for future studies investigating creative idea acceptance. Future research should follow-up on our findings by tracking more publications between FN, HN, and LN to gain a more complete picture of the fluctuations in creative idea acceptance over time.

Although previous research has studied Nobel laureates as a representative group of creative individuals (Jalil & Boujettif, 2005; Rothenberg, 1996; Shavinina, 2004; Zuckerman, 1967); only a very small percentage of scientists have had the honor of receiving the Nobel Prize. Furthermore, not all scientific disciplines fall into the prize areas of physics, chemistry, and medicine, thus, it is hard to generalize our findings to all scientists, or even to all scientists within physics, chemistry, or medicine.

Conclusions

Although further research is required in order to gain a more complete understanding of how creative idea acceptance occurs over time, our findings indicate that creative idea acceptance varies over the Nobel laureates' Nobel idea publishing careers. In general our findings support that Nobel idea acceptance fluctuates by publication, with HN being the most accepted Nobel idea publication, followed by FN, and then followed by LN (LN < FN < HN). We also found that Nobel idea acceptance does not follow a linear path, and that idea acceptance does not rise continuously across the Nobel laureates' Nobel idea publishing careers. Furthermore, we found that Nobel idea acceptance does not remain stable over the Nobel laureates' Nobel idea publishing careers, and may vary depending on discipline (physics, chemistry, or medicine).

Importantly, this study also demonstrates how measures of academic influence such as citation count, journal impact factor, journal cited half-life, and Eigenfactor score may be used to gain insight into how creative idea acceptance occurs specifically in science Nobel laureates. By using these measures of academic influence, we attempted to demonstrate that measures of academic influence can be used in the study of creativity. Although measures of academic influence (such as the measures used in this study) have been suggested for use in creativity research, few studies have actually utilized them (Gardner, 1988). In this study, we attempted to use such measures to quantify creativity theories that claim creative idea acceptance occurs overtime. Future research should seek to build on our findings by using measures of academic influence to measure creative idea acceptance in more Nobel publications in the Nobel laureates' careers, and in scientists other than Nobel laureates.

Overall, by studying creative idea acceptance through eminent creative individuals such as Nobel laureates, we can come to better understand creativity in general. As seen in the present study, a discipline's field of experts play a key role in whether or not an idea is accepted as creative (Csikszentmihalyi, 1996; Csikszentmihalyi, 1999; Gardner, 1988). Ultimately, the creative ideas that are accepted, progress our world through technological and societal advancements (Rubenson & Runco, 1992; Runco, 2004). Therefore, the study of creative idea acceptance is important in order to understand how creativity operates within science, our society, and the world.

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Table 1

Descriptive Statistics for Analyzed Measures of Acceptance by Publication and Prize Area

	(1) Impact Factor	(2) Citation Count	(3) Half-life	(4) Eigenfactor
Publication	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
A. First				
Physics	6.41 (5.05)	356.46 (1071.39)	8.05 (1.05)	.7333 (.55)
Chemistry	13 .06 (13.07)	639.39 (1947.83)	8.33 (1.24)	.7408 (.68)
Medicine	18.73 (13.08)	464.95 (684.76)	8.38 (0.98)	.7170 (.66)
Total	12.68 (12.05)	482.37 (1324.66)	8.26 (1.10)	.7295 (.63)
B. Highest Cited				
Physics	9.09 (9.84)	1084.57 (1756.05)	8.16 (1.14)	.7152 (.58)
Chemistry	19.63 (13.56)	1767.93 (2461.83)	8.40 (1.27)	.7597 (.70)
Medicine	24.93 (11.82)	1581.69 (1702.78)	8.67 (0.75)	.8908 (.74)
Total	17.80 (13.47)	1467.04 (2001.90)	8.41(1.08)	.7947 (.68)
C. Last				
Physics	7.84 (10.04)	32.02 (85.35)	7.71 (1.85)	.4595 (.54)
Chemistry	10.98 (10.52)	32.97 (92.71)	6.72 (2.14)	.4725 (.61)
Medicine	9.54 (9.17)	26.95 (51.64)	7.26 (1.72)	.4423 (.63)
Total	9.43 (9.93)	30.63 (78.11)	7.23 (1.94)	.4570 (.59)

NOTE: All values are rounded to two decimal points except for Eigenfactor mean score which was rounded to four decimal points.

Table 2.1

Correlation Table for First Nobel Idea Publication (FN) by Acceptance Measure

Measure	1	2	3	4	5	6	7	8
1. 2009 Impact Factor	-	.91*	1.00*	.52*	.98*	.19	.92*	.30*
2. Pub. Year Impact Factor	-	-	.93*	.23	.95*	.35	.87*	.11
3. 5 Year Impact Factor	-	-	-	.51*	.99*	.22*	.89*	.31*
4. 2008 Eigenfactor Score	-	-	-	-	.52*	-.14	.48*	.19
5. 2008 Article Influence	-	-	-	-	-	.22*	.89*	.29*
6. 2009 Half-life	-	-	-	-	-	-	.15	.10
7. 2009 Immediacy Index	-	-	-	-	-	-	-	.27*
8. 2010 Citation Count	-	-	-	-	-	-	-	-

* *p*<0.01

Table 2.2

Correlation Table for Highest Cited Nobel Idea Publication (HN) by Acceptance Measure

Measure	1	2	3	4	5	6	7	8
1. 2009 Impact Factor	-	.80*	.97*	.37*	.92*	.38*	.83*	.23*
2. Pub. Year Impact Factor	-	-	.89*	.36*	.93*	.49*	.71*	.39*
3. 5 Year Impact Factor	-	-	-	.34*	.97*	.42*	.88*	.23*
4. 2008 Eigenfactor Score	-	-	-	-	.33*	-.08	.34*	.24*
5. 2008 Article Influence	-	-	-	-	-	.47*	.86*	.24*
6. 2009 Half-life	-	-	-	-	-	-	.15	.17
7. 2009 Immediacy Index	-	-	-	-	-	-	-	.17
8. 2010 Citation Count	-	-	-	-	-	-	-	-

* *p*<0.01

Table 2.3

Correlation Table for Last Nobel Idea Publication (LN) by Acceptance Measure

Measure	1	2	3	4	5	6	7	8
1. 2009 Impact Factor	-	.99*	.56*	.37*	.96*	.23*	.87*	.15
2. Pub. Year Impact Factor	-	-	.52*	.46*	.97*	.21	.90*	.10
3. 5 Year Impact Factor	-	-	-	.15	.55*	.13	.52*	.08
4. 2008 Eigenfactor Score	-	-	-	-	.33*	.24*	.19	.05
5. 2008 Article Influence	-	-	-	-	-	.31*	.92*	.14
6. 2009 Half-life	-	-	-	-	-	-	.30*	.02
7. 2009 Immediacy Index	-	-	-	-	-	-	-	.17
8. 2010 Citation Count	-	-	-	-	-	-	-	-

* *p*<0.01

Figure 3

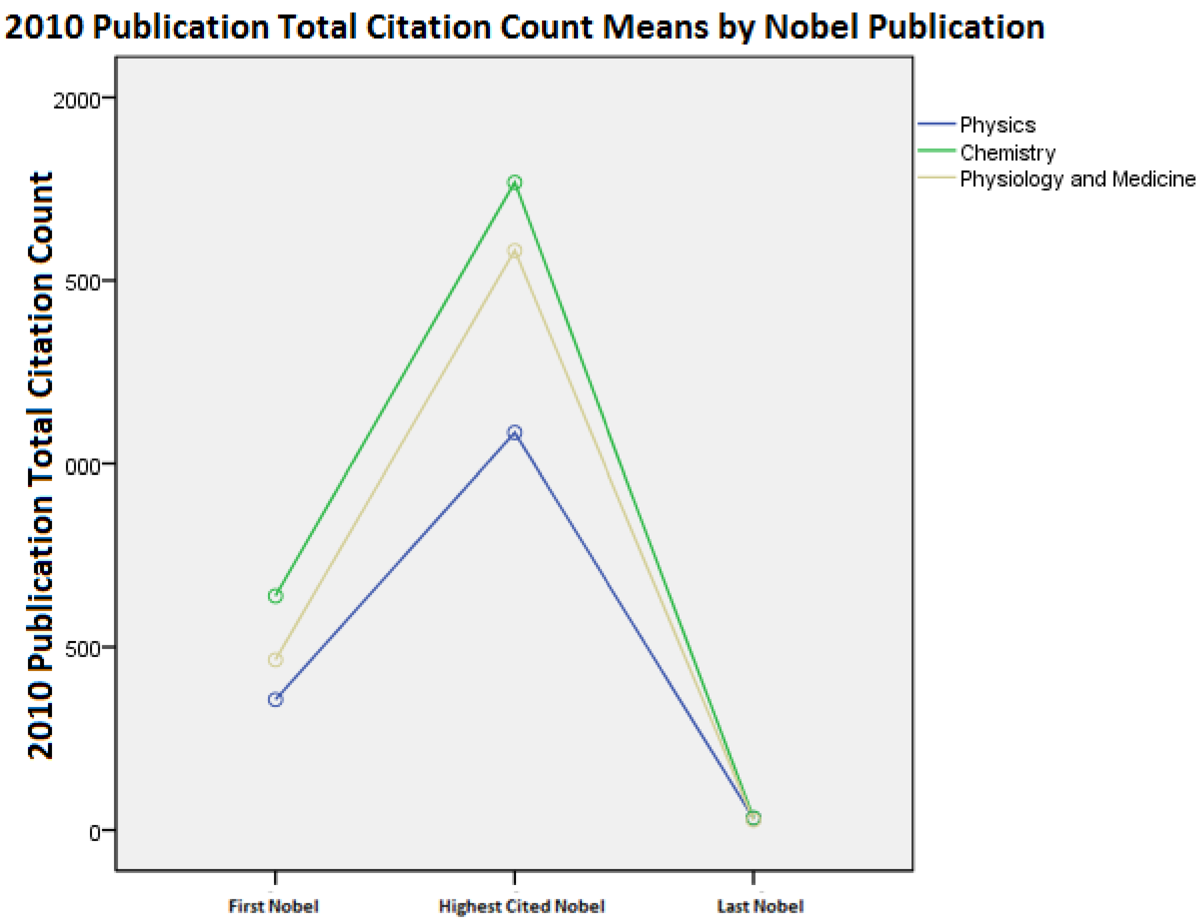

Figure 3. Mean 2010 publication total citation counts for FN, HN, and LN by prize area (physics, chemistry and medicine). Statistically significant differences were found between all publications (FN, HN, and LN), but no differences were found between prize areas.

Figure 4

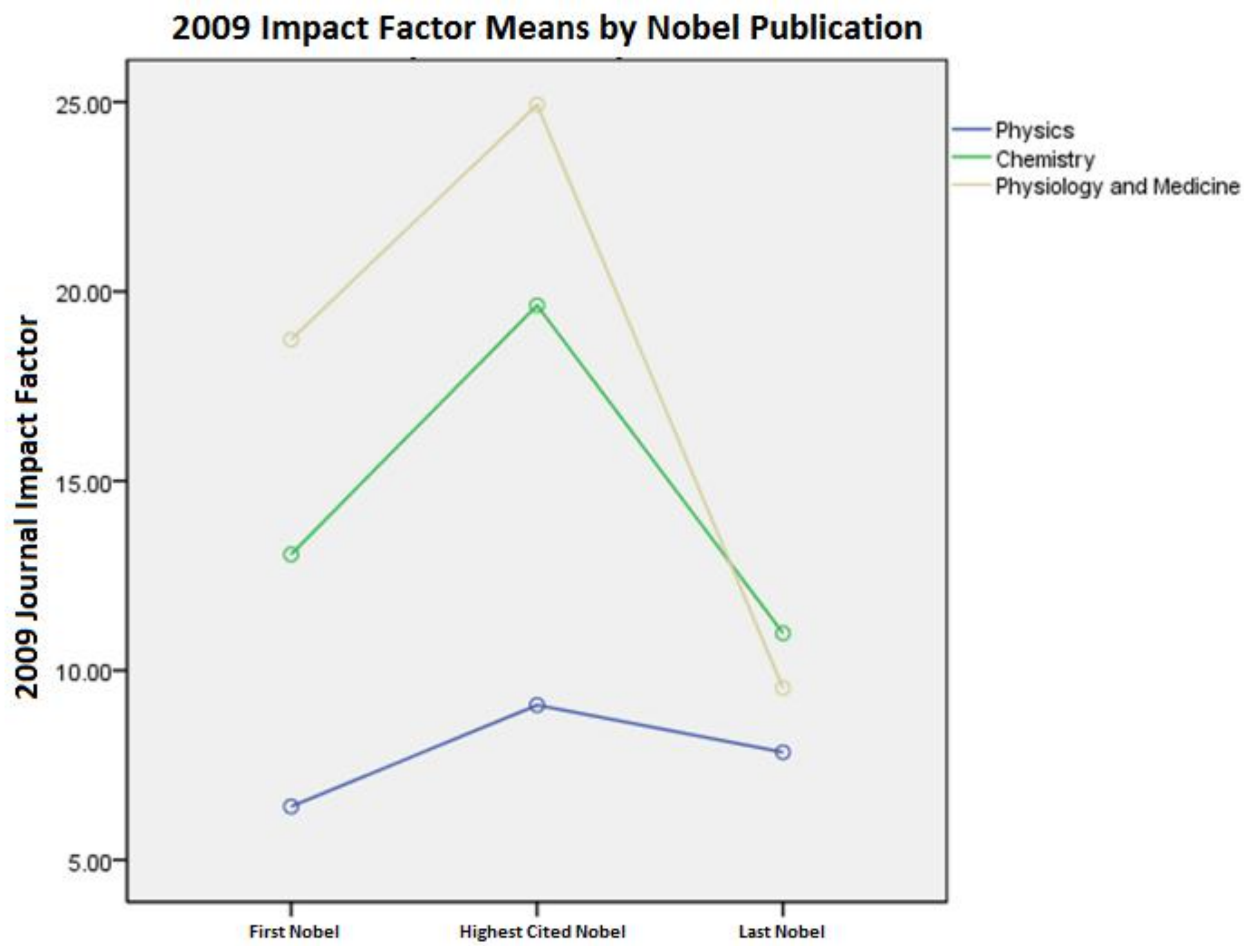

Figure 4. Mean 2009 journal impact factors for FN, HN, and LN by prize area (physics, chemistry and medicine). Statistically significant differences were found between all publications (FN, HN, and LN) and between prize areas.

Figure 5

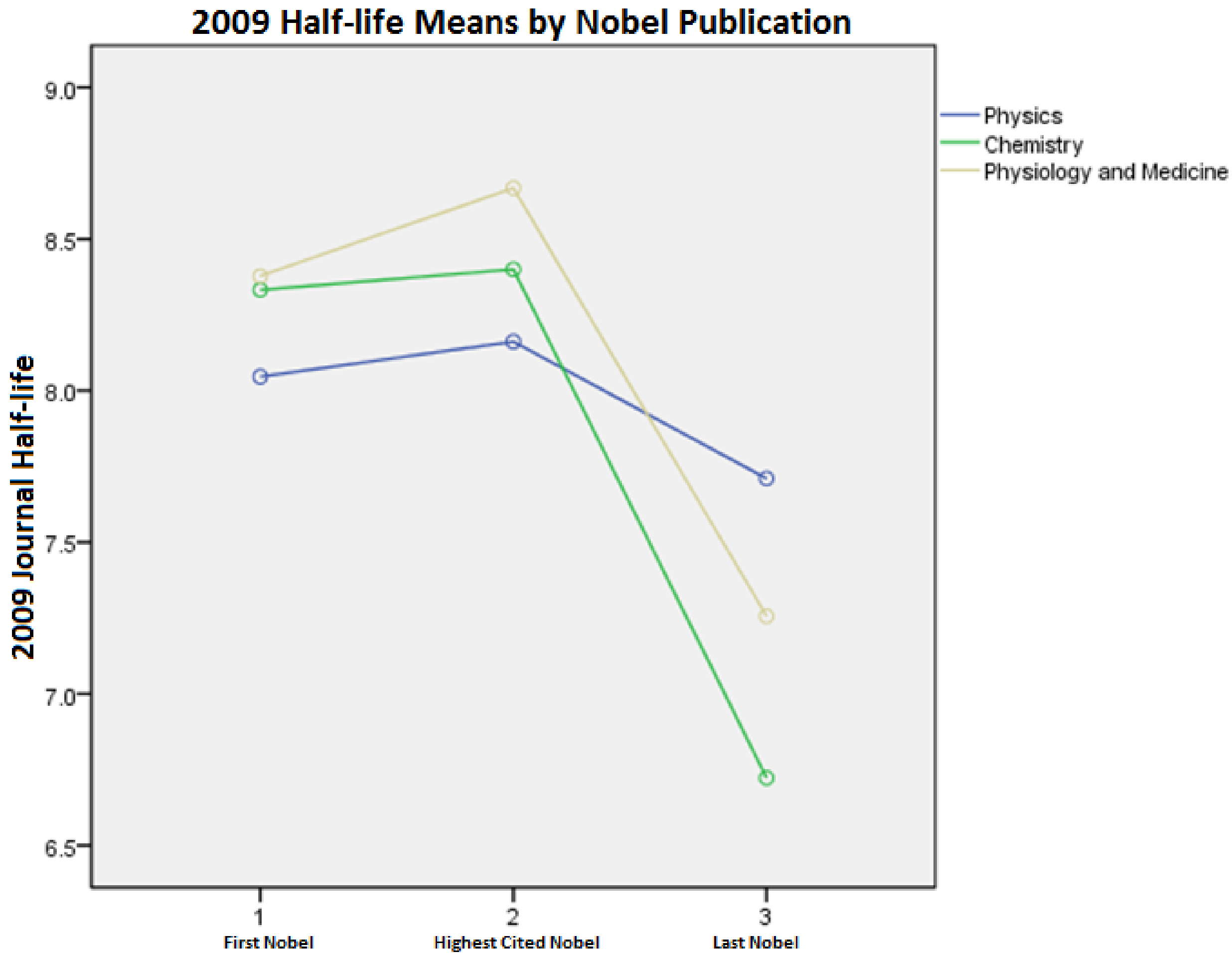

Figure 5. Mean 2009 journal cited half-life for FN, HN, and LN by prize area (physics, chemistry and medicine). Statistically significant differences were found between FN and LN, and HN and LN for chemistry and medicine. However, no differences were found between FN, HN, and LN for physics.

Figure 6

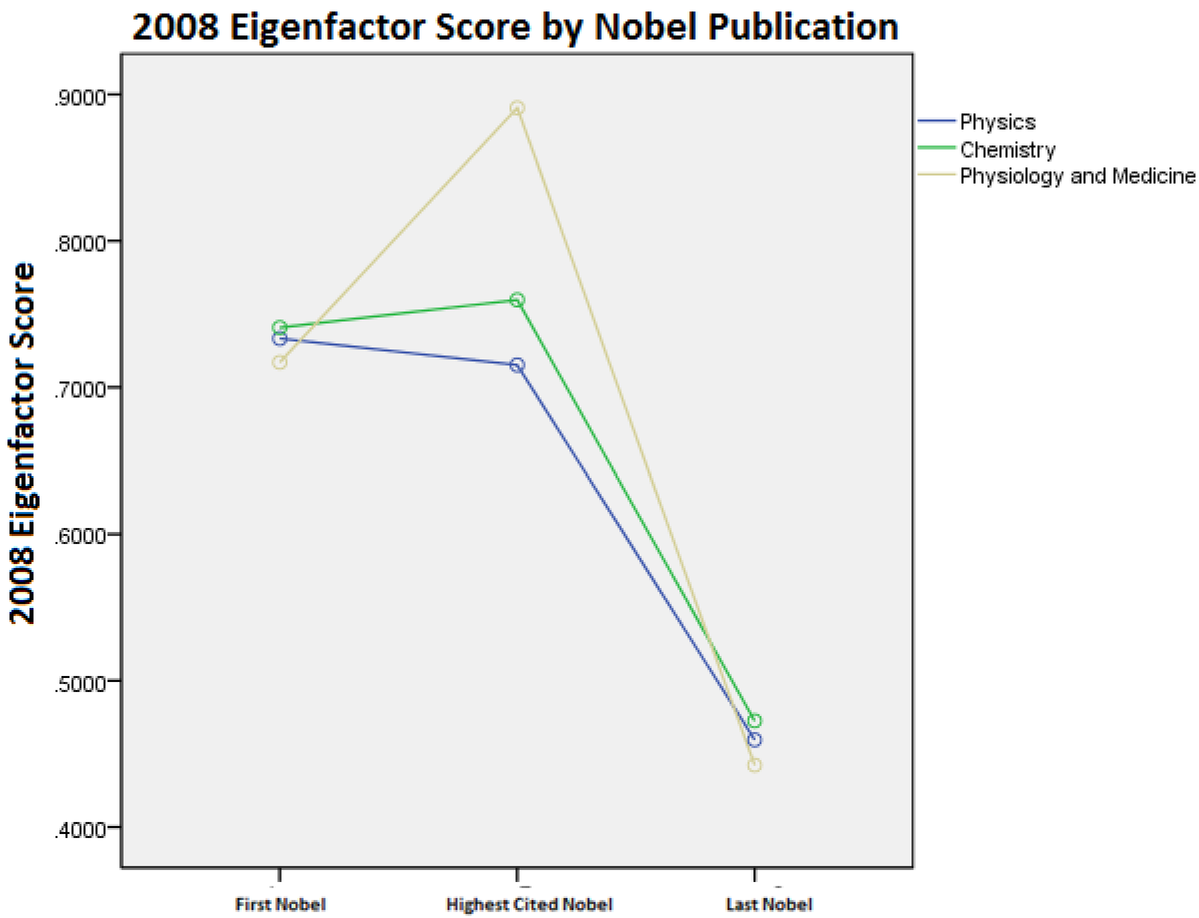

Figure 6. Mean 2008 Eigenfactor score for FN, HN, and LN by prize area (physics, chemistry and medicine). Statistically significant differences were found between FN and LN, and HN and LN. However, there were no significant differences between FN and HN.

Appendix A

Table A1

Listing of Nobel Laureates (included in this analysis) with Nobel Idea and Key Word

Year	Nobel Laureate	Nobel Idea	Nobel Idea Key Word
1980	Walter Gilbert	contributions concerning the determination of base sequences in nucleic acids	base
1980	Paul Berg	fundamental studies of the biochemistry of nucleic acids, with particular regard to recombinant-DNA	DNA
1980	James Watson Cronin	discovery of violations of fundamental symmetry principles in the decay of neutral K-MESONS	decay
1980	Val Logsdon Fitch	discovery of violations of fundamental symmetry principles in the decay of neutral K-MESONS	decay
1980	Roger W. Sperry	discoveries concerning the functional specialization of the cerebral hemispheres	hemisphere
1980	Jean Dausset	discoveries concerning genetically determined structures on the cell surface that regulated immunological reactions	immune
1980	George D. Snell	discoveries concerning genetically determined structures on the cell surface that regulated immunological reactions	immune
1981	David H. Hubel	discoveries concerning information processing in the visual system	visual
1981	Torsten N. Wiesel	discoveries concerning information processing in the visual system	visual
1981	Baruj Benacerraf	discoveries concerning genetically determined structures on the cell surface that regulate immunological reactions	immune
1981	Nicolaas Bloembergen	contribution to the development of high-resolution electron spectroscopy	laser
1981	Arthur Leonard Schawlow	contribution to the development of high-resolution electron spectroscopy	spectroscopy
1981	Kai M. Siegbahn	contribution to the development of high-resolution electron spectroscopy	spectroscopy
1981	Roald Hoffmann	Theories, developed independently, concerning the course of chemical reactions	chemical
1982	Kenneth G. Wilson	for his theory for critical phenomena in connection with phase transitions	critical phenomena
1982	Sune K. Bergstrom	discoveries concerning prostaglandins and related biologically active substances	prostaglandin
1982	Bengt I. Samuelsson	discoveries concerning prostaglandins and related biologically active substances	prostaglandin
1982	John R. Vane	discoveries concerning prostaglandins and related biologically active substances	prostaglandins
1982	Aaron Klug	development of crystallographic electron microscopy and his structural elucidation of biologically important nucleic acid-protein complexes	nucleic acid
1983	William Alfred Fowler	theoretical and experimental studies of the nuclear reactions of importance in the formation of the chemical elements in the universe	nuclear
1983	Henry Taube	the mechanisms of electron transfer reactions, especially in metal complexes	electron transfer
1984	Carlo Rubbia	decisive contributions to the large project, which led to the discovery of the field particles W and Z, communicators of weak interaction	particles
1984	Niels K. Jerne	theories concerning the specificity in development and control of the immune system and the discovery of the principle for production of monoclonal an	immune
1984	Cesar Milstein	Theories concerning the specificity in development and control of the immune system and the discovery of the principle for production of monoclonal...	antibody
1984	Robert Bruce Merrifield	Development of methodology for chemical synthesis on a solid matrix	solid
1985	Michael S. Brown	discoveries concerning the regulation of cholesterol metabolism	cholesterol metabolism
1985	Joseph L. Goldstein	discoveries concerning the regulation of cholesterol metabolism	cholesterol metabolism
1985	Herbert A. Hauptman	Outstanding achievements in the development of direct methods for the determination of crystal structures	crystal
1985	Jerome Karle	Outstanding achievements in the development of direct methods for the determination of crystal structures	crystal
1986	Ernst Ruska	fundamental work in electron optics, and for the design of the first electron microscope	microscope
1986	Gerd Binnig	design of the scanning tunneling microscope	microscope
1986	Heinrich Rohrer	design of the scanning tunneling microscope	microscope
1986	Stanley Cohen	discoveries of growth factors	growth factor
1986	Dudley R. Herschbach	contributions concerning the dynamics of chemical elementary processes	chemical
1986	Yuan Tseh Lee	contributions concerning the dynamics of chemical elementary processes	chemical
1986	John Charles Polanyi	contributions concerning the dynamics of chemical elementary processes	chemical
1987	J. Georg Bednorz	important breakthrough in the discovery of superconductivity in ceramic materials	superconductivity
1987	K. Alexander Muller	important breakthrough in the discovery of superconductivity in ceramic materials	superconductivity
1987	Susumu Tonegawa	discovery of the genetic principle for generation of antibody diversity	antibody
1987	Jean-Marie Lehn	development and use of molecules with structure- specific interactions of high selectivity	molecules
1988	Gertrude B. Elion	discoveries of important principles for drug treatment	chemotherapy
1988	Leon M Lederman	neutrino beam method and the demonstration of the doublet structure of the leptons	muon

		through the discovery of the muon neutrino	
1988	Melvin Schwartz	neutrino beam method and the demonstration of the doublet structure of the leptons through the discovery of the muon neutrino	neutrino
1988	Jack Steinberger	neutrino beam method and the demonstration of the double structure of the leptons through the discovery of the muon neutrino	neutrino
1988	Sir James W. Black	discoveries of important principles for drug treatment	antagonism
1988	George H. Hitchings	discoveries of important principles of drug treatment	dihydrofolate-reductase
1988	Johann Deisenhofer	determination of the three-dimensional structure of a photosynthetic reaction center	photosynthetic
1988	Robert Huber	the determination of the three-dimensional structure of a photosynthetic reaction centre	photosynthetic
1988	Hartmut Michel	the determination of the three-dimensional structure of a photosynthetic reaction centre	photosynthetic
1989	J. Michael Bishop	discovery of the cellular origin of retroviral oncogenes	oncogenes
1989	Norman F. Ramsey	invention of the separated oscillatory fields method and its use in the hydrogen maser and other atomic clocks	oscillatory
1989	Hans G. Dehmelt	development of the ion trap technique	ion
1989	Harold E. Varmus	discovery of the cellular origin of retroviral oncogenes	retroviral
1989	Sidney Altman	discovery of catalytic properties of RNA	catalytic
1989	Thomas R. Cech	discovery of catalytic properties of RNA	catalytic
1990	Jerome I. Friedman	pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons which have been essential importance for...	inelastic
1990	Henry W. Kendall	pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons which have been essential importance for...	inelastic
1990	Richard E. Taylor	pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons which have been essential importance for...	inelastic
1990	Joseph E. Murray	discoveries concerning organ and cell transplantation in the treatment of human disease	transplantation
1990	E. Donnall Thomas	their discoveries concerning organ and cell transplantation in the treatment of human disease	transplantation
1990	Elias James Corey	development of the theory and methodology of organic synthesis	organic synthesis
1991	Erwin Neher	discoveries concerning the function of single ion channels in cells	ion channels
1991	Bert Sakmann	discoveries concerning the function of single ion channels in cells	ion
1991	Richard R. Ernst	contributions to the development of the methodology of high resolution nuclear magnetic resonance (NMR) spectroscopy	nmr
1992	Georges Charpak	invention and development of particle detectors, in particular the multiwire proportional chamber	multiwire
1992	Edmond H. Fischer	discoveries concerning reversible protein phosphorylation as a biological regulatory mechanism	phosphorylation
1992	Edwin G. Krebs	discoveries concerning reversible protein phosphorylation as a biological regulatory mechanism	phosphorylation
1992	Rudolph A. Marcus	contributions to the theory of electron transfer reactions in chemical systems	electron
1993	Kary B. Mullis	invention of the polymerase chain reaction (PCR) method	polymerase
1993	Michael Smith	discovery of split genes	genes
1993	Russell A. Hulse	discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation	pulsar
1993	Joseph H. Taylor Jr.	discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation	pulsar
1993	Phillip A. Sharp	discoveries of split genes	genes
1994	Bertram N. Brockhouse	development of neutron spectroscopy	neutron
1994	Clifford G. Shull	development of the neutron diffraction technique	neutron diffraction
1994	Alfred G. Gilman	discovery of g proteins and the role of these proteins in signal transduction in cells	g proteins
1994	Martin Rodbell	discovery of g proteins and the role of these proteins in signal transduction in cells	transduction
1994	George A. Olah	contributions to carbocation chemistry	carbocation
1995	Martin L. Perl	discovery of tau lepton	tau lepton
1995	Frederick Reines	detection of the neutrino	neutrino
1995	Edward B. Lewis	discoveries concerning the genetic control of early embryonic development	embryonic
1995	Eric F. Wieschaus	discoveries concerning the genetic control of early embryonic development	embryo
1995	Paul J. Crutzen	work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone	ozone
1995	Mario J. Molina	work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone	ozone
1995	F. Sherwood Rowland	work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone	ozone
1996	David M. Lee	discovery of superfluidity in Helium-3	Helium
1996	Douglas D. Osheroff	discovery of superfluidity in Helium-3	Helium
1996	Paul C. Doherty	discoveries concerning the specificity of the cell mediated immune defense	immune
1996	Rolf M. Zinkernagel	discoveries concerning the specificity of the cell mediated immune defense	immune
1996	Robert F. Curl Jr.	discovery of fullerenes	fullerenes
1996	Sir Harold W. Kroto	discovery of fullerenes	fullerenes

1996	Richard E. Smalley	discovery of fullerenes	fullerenes
1997	Steven Chu	development of methods to cool and trap atoms with laser light	atoms
1997	Claude Cohen-Tannoudji	development of methods to cool and trap atoms with laser light	atoms
1997	William D. Phillips	development of methods to cool and trap atoms with laser light	atoms
1997	Stanley B. Prusiner	discovery of prions- a new biological principle of infection	prions
1997	Paul D. Boyer	elucidation of the enzymatic mechanism underlying the synthesis of adenosine triphosphate	ATP
1997	John E. Walker	elucidation of the enzymatic mechanism underlying the synthesis of adenosine triphosphate	ATP
1997	Jens C. Skou	first discovery of an ion-transporting enzyme, Na+, K+- ATPase	Na K
1998	Ferid Murad	discoveries concerning nitric oxide as a signaling molecule in the cardiovascular system	nitric oxide
1998	Robert B. Laughlin	discovery of a new form of quantum fluid with fractionally charged excitations	quantum
1998	Horst L. Stormer	discovery of a new form of quantum fluid with fractionally charged excitations	quantum
1998	Daniel C. Tsui	discovery of a new form of quantum fluid with fractionally charged excitations	excitations
1998	Robert F. Furchgott	discoveries concerning nitric oxide as a signaling molecule in the cardiovascular system	nitric oxide
1998	Louis J. Ignarro	discoveries concerning nitric oxide as a signaling molecule in the cardiovascular system	nitric oxide
1998	Walter Kohn	his development of the density- functional theory	density- functional
1998	John A. Pople	development of computational methods in quantum chemistry	quantum
1999	Gerardus 't Hooft	elucidating the quantum structure of electroweak interactions in physics	quantum
1999	Gunter Blobel	discovery that proteins have intrinsic signals that govern their transport and localization in the cell	protein
1999	Ahmed H. Zewail	studies of the transition states of chemical reactions using femtosecond spectroscopy	spectroscopy
2000	Zhores I. Alferov	developing semiconductor heterostructures used in high-speed and opto-electronics	semiconductor
2000	Jack S. Kilby	his part in the invention of the integrated circuit	circuit
2000	Herbert Kroemer	developing semiconductor heterostructures used in high speed and opto-electronics	semiconductor
2000	Arvid Carlsson	discoveries concerning signal transduction in the nervous system	nervous system
2000	Paul Greengard	discoveries concerning signal transduction in the nervous system	nervous system
2000	Eric R. Kandel	discoveries concerning signal transduction in the nervous system	nervous system
2000	Alan J. Heeger	discovery and development of conductive polymers	polymers
2000	Alan G. MacDiarmid	discovery and development of conductive polymers	polymers
2000	Hideki Shirakawa	discovery and development of conductive polymers	polymers
2001	Eric A. Cornell	acheivement of bose-einstein condensation in dillute gases of alkali atoms, and for early fundamental studies of the properties of the condensates	bose-einstein
2001	Wolfgang Ketterle	acheivement of bose-einstein condensation in dillute gases of alkali atoms, and for early fundamental studies of the properties of the condensates	bose-einstein
2001	Carl E. Wieman	acheivement of bose-einstein condensation in dillute gases of alkali atoms, and for early fundamental studies of the properties of the condensates	bose-einstein
2001	Leland H. Hartwell	discoveries of key regulators of the cell cycle	cell cycle
2001	R. Timothy Hunt	discoveries of key regulators of the cell cycle	cell cycle
2001	Sir Paul M. Nurse	discoveries of key regulators of the cell cycle	cell cycle
2001	William S. Knowles	their work on chirally catalysed hydrogenation reactions	hydrogenation
2001	Ryoji Noyori	their work on chirally catalysed hydrogenation reactions	chiral
2001	K. Barry Sharpless	work on chirally catalysed oxidation reactions	oxidation
2002	Raymond Davis Jr.	pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos	neutrino
2002	Masatoshi Koshiba	pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos	neutrino
2002	Riccardo Giacconi	Pioneering contributions to astrophysics, which have led to the discovery of cosmic x-ray sources	x-ray
2002	H. Robert Horvitz	discoveries concerning genetic regulation of organ development and programmed cell death	cell death
2002	John E. Sulston	discoveries concerning genetic regulation of organ development and programmed cell death	cell death
2002	John B. Fenn	development of soft desorption ionisation methods for mass spectrometric analyses of biological macromolecules	desorption
2002	Koichi Tanaka	development of soft desoption ionisation methods for mass spectrometric analyses of biological macromolecules	desorption
2002	Kurt Wuthrich	development of nuclear magnetic resonance spectroscopy for determining the three dimensional structure of biological macromolecules in solution	spectroscopy
2003	Alexei A. Abrikosov	pioneering contributions to the theory of superconductors and superfluids	superconductor
2003	Vitaly L. Ginzburg	pioneering contributions to the theory of superconductors and superfluids	superfluid
2003	Anthony J. Leggett	pioneering contributions to the theory of superconductors and superfluids	superfluid
2003	Paul C. Lauterbur	discoveries concerning magnetic resonance imaging	magnetic resonance
2003	Sir Peter Mansfield	discoveries concerning magnetic resonance imaging	magnetic resonance
2003	Peter Agre	discovery of water channels	water channels
2003	Roderick MacKinnon	structural and mechanistic studies of ion channels	ion channels

2004	Linda B. Buck	discoveries of odorant receptors and the organization of the olfactory system	olfactory
2004	David J. Gross	discovery of asymptotic freedom in the theory of the strong interaction	strong
2004	H. David Politzer	discovery of asymptotic freedom in the theory of the strong interaction	strong
2004	Frank Wilczek	discovery of asymptotic freedom in the theory of the strong interaction	strong
2004	Richard Axel	discoveries of odorant receptors and the organization of the olfactory system	olfactory
2004	Aaron Ciechanover	discovery of ubiquitin-mediated protein degradation	ubiquitin
2004	Avram Hershko	discovery of ubiquitin-mediated protein degradation	ubiquitin
2005	Roy J. Glauber	contribution to the quantum theory of optical coherence	quantum
2005	John L. Hall	contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique	spectroscopy
2005	Theodor W. Hansch	contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique	spectroscopy
2005	Barry J. Marshall	discovery of the bacterium Heliobacter pylori and its role in gastritis and peptic ulcer disease	gastric
2005	J. Robin Warren	discovery of the bacterium Helicobacter pylori and its role in gastritis and peptic ulcer disease	gastric
2005	Yves Chauvin	development of the metathesis method in organic synthesis	metathesis
2005	Robert H. Grubbs	development of the metathesis method in organic synthesis	metathesis
2005	Richard R. Schrock	development of the metathesis method in organic synthesis	metathesis
2006	John C. Mather	discovery of the blackbody form and anisotropy of the cosmic microwave background radiation	cosmic microwave
2006	George F. Smoot	discovery of the blackbody form and anisotropy of the cosmic microwave background radiation	cosmic microwave
2006	Andrew Z. Fire	discovery of rna interference- gene silencing by double stranded rna	rna
2006	Craig C. Mello	discovery of rna interference- gene silencing by double-stranded rna	rna
2006	Roger D. Kornberg	studies of the molecular basis of eukaryotic transcription	transcription
2007	Gerhard Ertl	studies of chemical processes on solid surfaces	surface
2007	Albert Fert	discovery of giant magnetoresistance	magnetoresistance
2007	Peter Grunberg	disocovery of giant magnetoresistance	magnetoresistance
2007	Mario R. Capecchi	discoveries of principles for introducing specific gene modifications in mice by the use of embryonic stem cells	stem cells
2007	Sir Martin J. Evans	discoveries of principles for introducing specific gene modifications in mice by the use of embryonic stem cells	mouse embryos
2007	Oliver Smithies	discoveries of principles for introducing specific gene modifications in mice by the use of embryonic stem cells	stem cells
2008	Osamu Shimomura	discovery and development of the green fluorescent protein, gfp	protein
2008	Martin Chalfie	discovery and development of the green fluorescent protein, GFP	protein
2008	Roger Y. Tsien	discovery and development of the green florescent protein gfp	protein
2008	Yoichiro Nambu	discovery of the mechanism of spontaneous broken symmetry in subatomic physics	symmetry
2008	Makoto Kobayashi	discovery of the origin of the broken symmetry which predicts the existence of at least 3 families of quarks in nature	quark
2008	Toshihide Maskawa	discovery of the origin of the broken symmetry which predicts the existence of at least three families of quarks in nature	symmetry
2008	Harald zur Hausen	discovery of human papilloma viruses causing cervical cancer	papilloma
2008	Françoise Barré-Sinoussi	discovery of HIV	HIV
2008	Luc Montagnier	discovery of HIV	HIV
2009	Charles K. Kao	achievements concerning the transmission of light in fibers for optical communication	optical
2009	Willard S. Boyle	invention of an imaging semiconductor circuit	semiconductor
2009	George E. Smith	invention of an imaging semiconductor circuit	ccd
2009	Venkatraman Ramakrishnan	studies of the structure and function of the ribosome	ribosome
2009	Thomas A. Steitz	studies of the structure and function of the ribosome	ribosome
2009	Ada E. Yonath	studies of the structure and function of the ribsome	ribosome
2009	Elizabeth H. Blackburn	discovery of how chromosomes are protected by telomeres and the enzyme telomerase	telomeres
2009	Carol W. Greider	discovery of how chromosomes are protected by telomeres and the enzyme telomerase	telomeres
2009	Jack W. Szostak	discovery of how chromosomes are protected by telomeres and the enzyme telomerase	telomeres